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Pure-sulfide CZTS solar cells by pulsed laser deposition

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Deposition parameters	Target	Annealed in	Device structure
<ul style="list-style-type: none"> Temperature: 25°C Base pressure: 10⁻⁷ mbar Laser: Excimer KrF 248 nm, 20 ns pulse @10Hz 	Compound Cu ₂ ZnSnS ₄ (Cu/Zn = 1.8)	100 mbar N ₂ 200 mg S 570°C 10 min	Mo – 600 nm - DC sputtering CZTS – 800 nm - pulsed laser deposition CdS – 70 nm - chemical bath deposition ZnO/AZO – 70/250 nm - RF sputtering

??? Why pulsed laser deposition ???

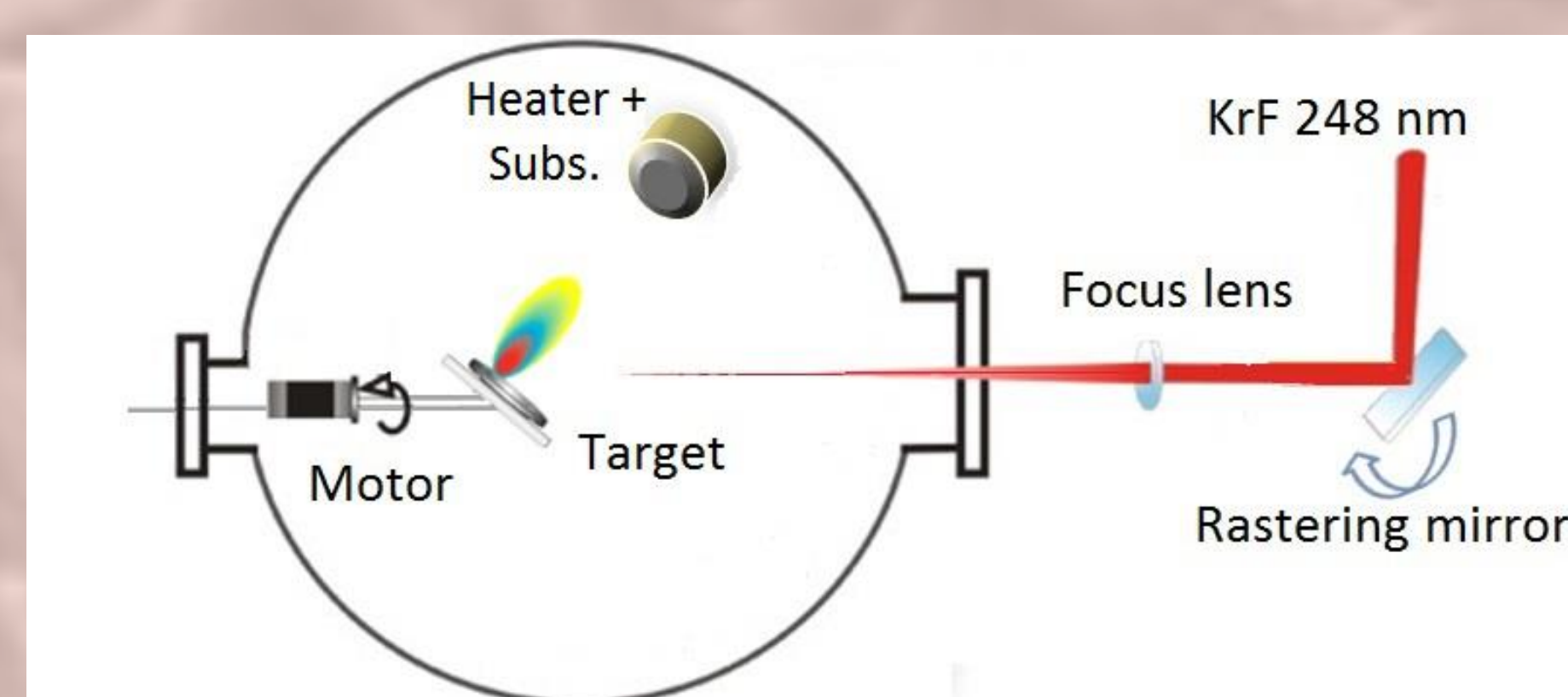
PROS	CONS
<ol style="list-style-type: none"> Many tunable parameters Kinetic energy of ablated species promotes surface mobility at the substrate Non-equilibrium deposition conditions → control over defect formation? 	<ol style="list-style-type: none"> Complex physics Expensive production method Radially inhomogeneous flux of species Ejection of micro-particulate (solved after annealing!)

Pulsed laser deposition setup

Laser fluence = pulse energy / beam area

Pulse energy: constant over 1 hour deposition time

Beam area: tuned by changing the **lens-target distance**



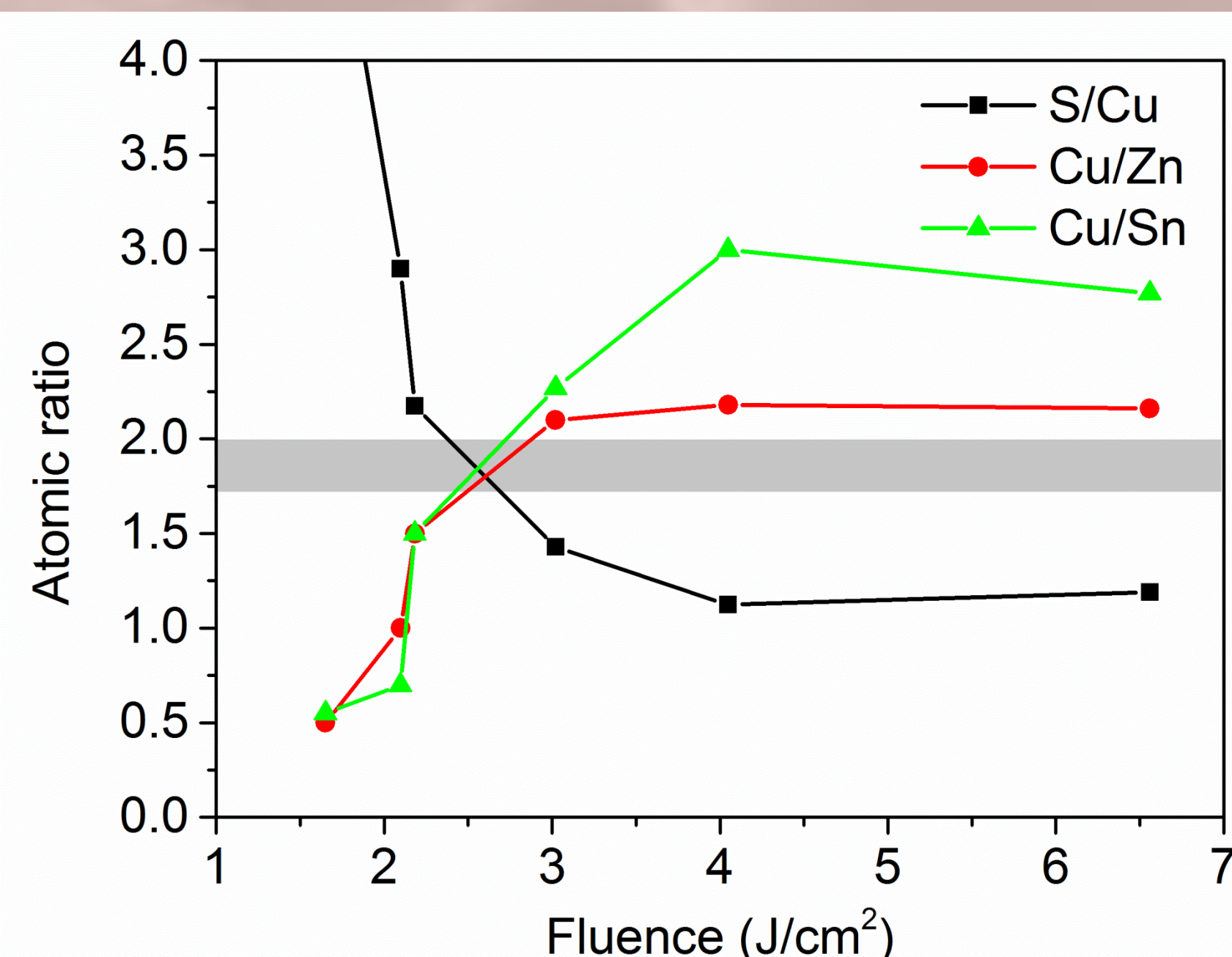
Very low fluence:
evaporation
Very high fluence:
ablation

Influence of laser fluence on composition

Copper has the lowest vapour pressure among the 4 elements

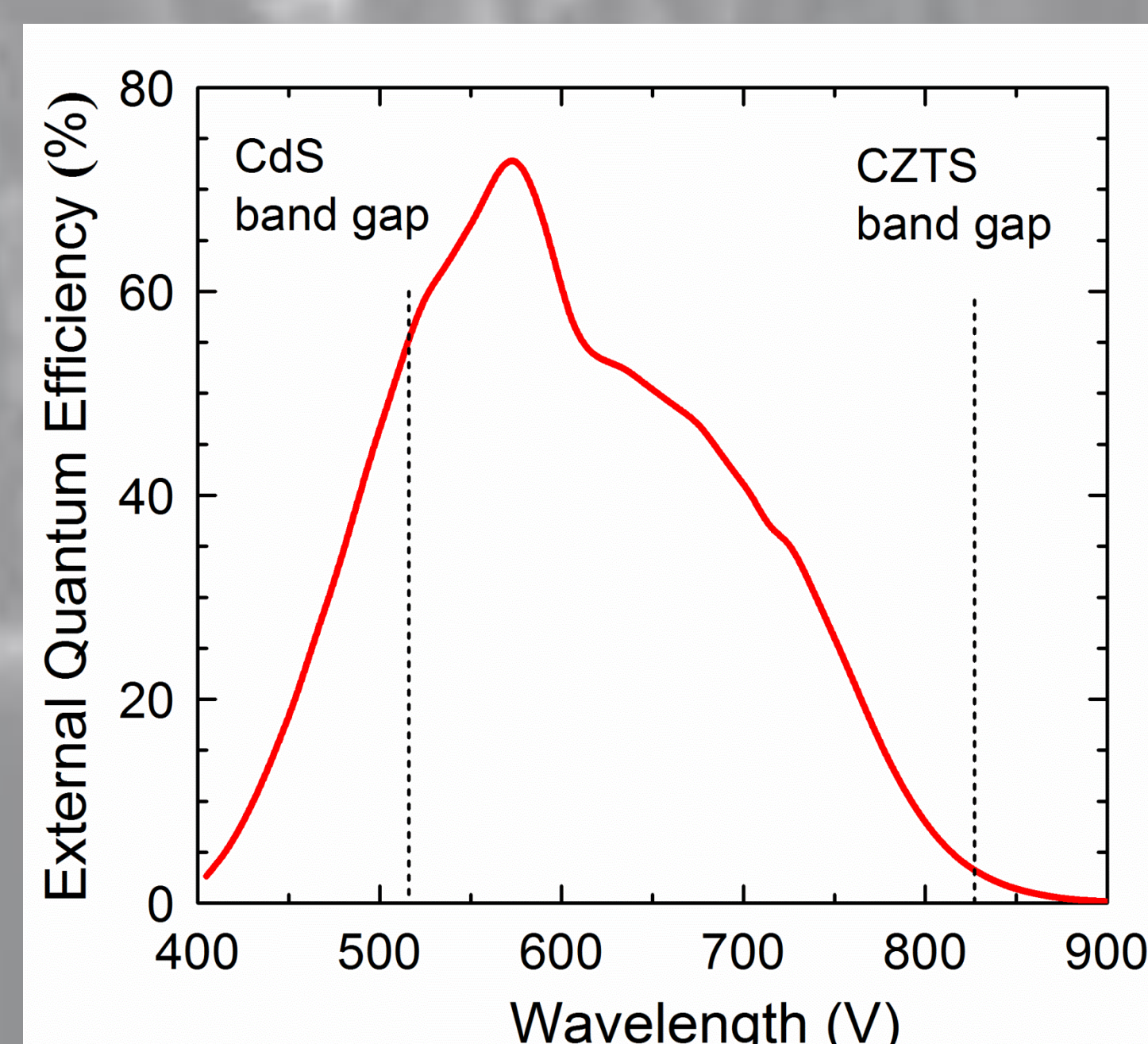
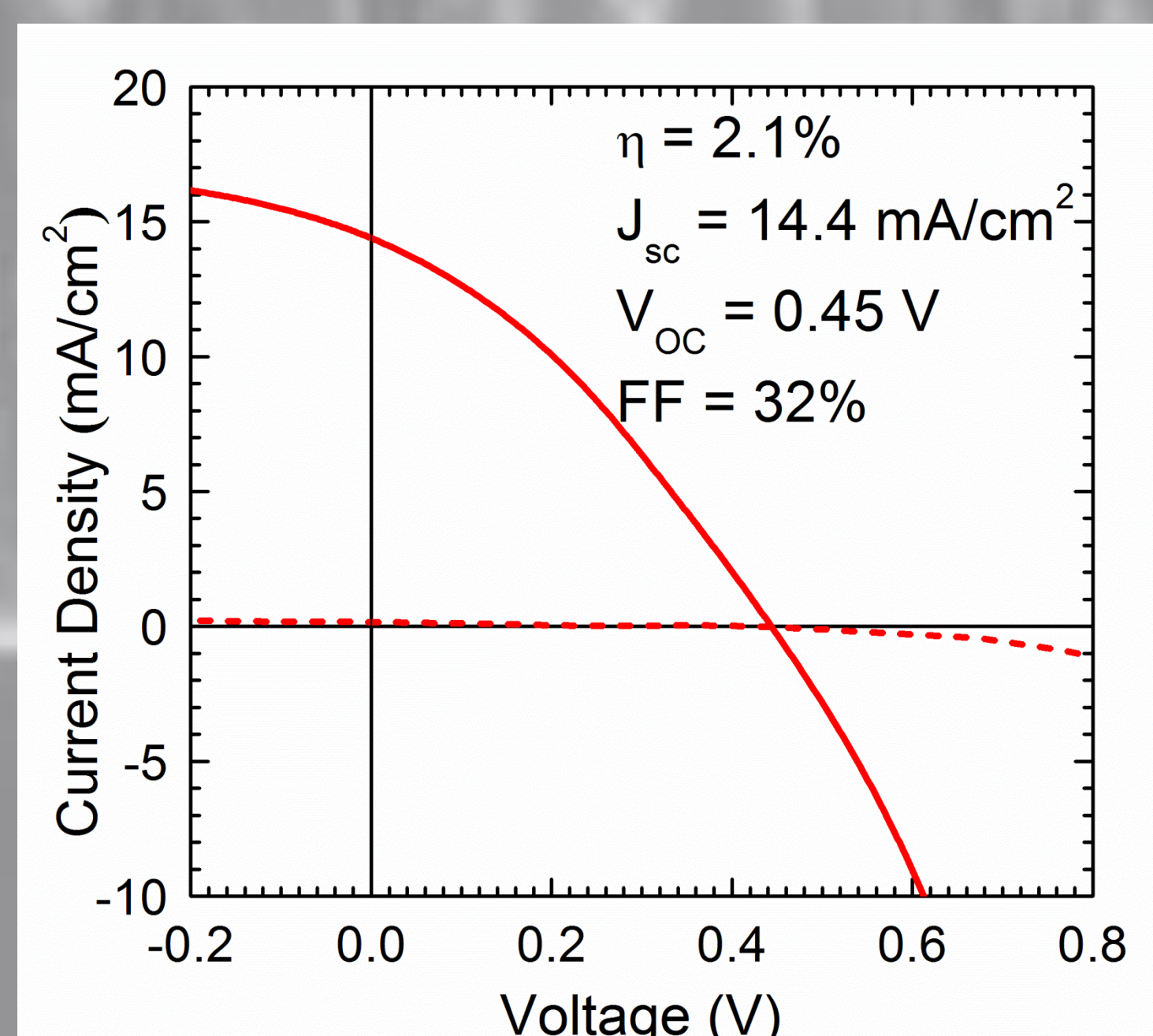


Tuning laser fluence
= tuning %Cu



At optimal lens position:

Cu: **22.6%**; Zn: **14.7%**; Sn: **12.2%**; S: **50.5%**
Cu / (Zn+Sn) = **0.84**; Zn/Sn = **1.20**; Cu/Sn = **1.85**



Conclusions

Solar cell devices	CZTS processing
<ol style="list-style-type: none"> J_{sc} and V_{oc} are relatively close to best devices Fill factor is very low Extreme light-dark crossover 	<ol style="list-style-type: none"> Compact morphology with large grains Micro-particulate disappears after annealing Radial compositional inhomogeneities

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